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Pasadena, October 10, 2003

Andreas Aebe, Ph.D.

Director

Document/s attached:

- German Patent Application DE 1 085 699  
Elektrische Einrichtung zum statischen Auf - bzw. Abrunden  
[Electrical device for statistical rounding up and rounding down]

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**PUBLISHED EXAMINED PATENT APPLICATION 1,085,699**  
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Electrical device for statistical rounding up and rounding down

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The invention concerns a device for statistical rounding up and rounding down.

In all accounting and statistics tasks that do not have to be performed with absolute accuracy for financial or fiscal purposes or the like, but are permissible with limited accuracy for production scheduling, for example, the size, i.e., the number of digits of the required data storage is a defining factor in the cost and the profitability of the system. To reduce storage overhead, it is, consequently, possible to make use of the knowledge that, with statistically controlled up and down rounding of the numbers to an upper and a lower limit and with large numbers of accounting items, the same mathematically accurate results of the addition are obtained as with the addition of the numbers themselves. If single-digit powers of 10 are selected as limits, a significant savings of storage capacity is thus achieved. The essence of statistical rounding up or rounding down consists in that the statistical probability of being rounded up to the upper limit corresponds to the number itself, [and the probability] of being rounded down to the lower limit is proportional to the complement of the number. This means that, for example, all numbers of the value  $n = 75$  are rounded up in exactly 75% of all cases to  $m = 1 \cdot 10^2 = 100$  and are, in 25% of all cases, rounded down to 0, i.e., are not considered if the upper limit is assumed to be to  $m = 1 \cdot 10^2$  and the lower limit is assumed to be 0.

It is, to be sure, possible to perform such a statistical rounding up and rounding down by using electronic computing or data processing systems by continuously generating multi-digit random numbers using one of the known processes and comparing the random number generated at the instant of the arrival of a numeric value to be posted with the posting number and by also storing the upper (or lower) limit controlled by the result of this comparison; however, this digital calculation requires a very costly program for the creation of random numbers and for the comparison and correspondingly great storage and programming capacity, by means of which a conventional electronic accounting system is rendered significantly more expensive.

The object of the invention is to report a simple electrical device for statistical rounding up and rounding down that can be used as a component in accounting systems or the like and in which the upper limit is assumed to be  $m = 10^x$  and the lower limit is assumed to be 0.

According to the invention, a display-output arrangement is provided with a scale including all  $x$ -digit numeric values that occur that is controlled by the number  $n$  such that the arrangement can be active only for the  $n/m$ -th portion of the range of the scale or can be active in a first manner for the  $n/m$ -th portion of the range of the scale and in a second manner for the  $(m-n)/m$ -th portion, and that means are provided to poll the scale at any selectable instant and make the downstream arrangement for the storage of the rounded-off number active for a period of time that is significantly smaller than that for running through the entire scale.

A cathode ray tube whose cathode-ray is guided over the screen with high frequency in one ( $x$ -) coordinate may, for example, serve as a display-output arrangement and is adjusted proportional to the numeric value  $n$  input in the other ( $y$ -) coordinate; moreover the cathode ray can deliver an output signal for a distance and equivalently for a period of time that is inversely proportional to its deflection in the  $y$ -direction. To generate the output signal, a metallic collector electrode that delivers an output voltage upon incidence

of a cathode ray and is designed in the form of a triangle bounded by a diagonal of the screen may be provided in the immediate vicinity of the screen.

Instead of this metallic electrode, an opaque triangular mask may also be provided and, in front of the screen, a photocell that is illuminated by the image spot if it is not covered and delivers an output signal accordingly.

The output signal then serves as an instruction for the rounding up to the upper limit  $m$ . The rounding down to the lower limit, in this case 0, occurs as a result of failure to detect the other numeric values.

However, it is also possible to ascertain both limits by providing two triangular electrodes or masks separated by a diagonal of the screen, which, together, detect the entire surface of the screen and deliver two differentiable output signals, e.g., for the lower limit  $m_u = 10^n$  and the upper limit  $m_o = 10^{n+x}$ . The connected counter of the accounting system must be made suitable for the input of counting pulses (bits) at two locations, i.e., in the lowest digit corresponding to  $10^n$  and a digit greater by the factor  $10^x$ , i.e., greater by  $x$  digits, whereby there must be continuous carrying.

The device according to the invention has the advantage that it enables significant reduction in the storage overhead of accounting systems equipped therewith, yet, delivers an exact result in the addition of any items. In large accounting systems, particularly if many storage areas are required for statistical partitioning and if relatively high digit numbers are to be stored, this means a significant savings.

The invention is explained in greater detail with reference to Fig. 1 and 2, by way of example. They depict:

Fig. 1                      two diagrams to explain statistical rounding up and rounding down compared to normal rounding,

Fig. 2a, 2b, 2c                    a device according to the invention using a cathode ray tube.

The diagrams of Fig. 1 serve to illustrate the difference between normal and statistical rounding up and down. In normal rounding off in the number range  $0 \dots 100$ , all numbers greater than 50 are rounded to 100 and all numbers smaller than 50 to 0. In diagram 1a, the numeric values  $n$  and the two limits 0 and 100 as limits are entered on the ordinate. The double line drawn is thus obtained as the boundary between rounding up and rounding down. A number above 50 is thus never rounded down and a number below 50 is never rounded up. However, this can cause gross errors if the numbers do not occur in a completely statistical distribution, i.e., all are not larger or smaller than 50 to the same extent in the long run.

Rounding up and rounding down can be performed better statistically; there, the statistical probability of rounding up is proportional to the numeric value and that of rounding down proportional to the complement of the numeric value. The diagram 1b shows this relationship graphically for the numbers  $0 < n < 100$  and the limits 0 and 100. To the left of the diagonals, there is the probability of rounding up, and to the right, that of rounding down. The number 75 is thus in 75 of 100 cases rounded up and in 25 of 100 cases rounded down.

Fig. 2a depicts an electrical device to perform this rounding up and rounding down.

To generate a statistical distribution to control the number-proportional rounding up, the cathode ray tube 1, whose cathode ray is guided over the entire width of the screen by the high frequency sawtooth wave deflecting voltage of the generator 2 in the  $x$ -direction over the entire width of the screen, is used. The width of the screen should correspond to the range of numbers  $0 < n < 100$ . A short output pulse controlled independently of the deflecting voltage can be considered as falling statistically randomly within a scanning line. The cathode ray is further deflected in the  $y$ -direction such that it passes through the  $x$ -direction at a specific  $y$ -value, i.e., draws the line 3. The deflection in the  $y$ -direction is controlled by the numbers to be rounded off such that the cathode ray writes the

uppermost line at the number 0 and the lowest line at the number 100. For this, the digital numbers are first converted in the code converter 4 into analog voltages that serve as deflecting voltages for the  $y$ -directions.

The triangular collector electrode 5 is located in the immediate vicinity of the screen in the interior of the tube. Its hypotenuse can deviate from a straight line in a correcting manner to compensate for any nonlinearity of the cathode ray tube. The collector electrode 5 is connected via the amplifier 6 and the coincidence gate 7 to the counter 8. The gate 7 is opened only when a corresponding pulse is present on the second input. This pulse is very short compared to the sawtooth interval; it is generated in the generator 9 when the number to be rounded off has entered completely. Then, a corresponding end signal is ascertained by the circuit 10 and the generator is activated thereby.

If, at the instant of the turning on of the collector electrode on the counter 8, the image spot is precisely on the collector electrode, a pulse can be stored that serves as a rounding-up instruction. If the image spot lies outside the electrode, no pulse is generated and the value of the number is thus suppressed, i.e., rounded down to 0 instead.

Instead of the collector electrode, it is also possible to use a similarly designed opaque masking plate arranged reflected on the diagonal (Fig. 2b). In this case, the photocell 11 that is illuminated by the image spot (if is not masked) is essential; however is only active and outputs a rounding-up pulse to the counter 8 if the gate 7 is opened.

It is unnecessary to describe the electrical means of the device in detail since this is a matter of circuit elements familiar to the person skilled in the art.

## CLAIMS:

1. Electrical device for statistical rounding up and rounding down of  $x$ -digit numbers  $n$  to two limit values, e.g., 0 and  $m = 10^x$ , in which the probability of rounding up to the upper limit  $m$  is proportionately  $n$  and the probability of rounding down to the lower limit 0 is proportionately  $(m-n)$ , characterized in that a display-output arrangement is provided with a scale including all possible numeric values  $0 \dots 10^x$  that is controlled by the numbers such that it can be active only for the  $n/m$ -th portion of the range of the scale, or can be active for the  $n/m$ -th portion in a first manner and can be active for the  $(m-n)/m$ -th portion in a second manner, in order to poll the scale in rapid sequence and to make the arrangement active for a period of time that is significantly less than the time required to poll the entire scale.
2. Device according to claim 1, characterized in that a cathode ray tube (1), whose cathode ray beam is guided with high frequency over the screen in one ( $x$ -) coordinate and is adjusted in the other ( $y$ -) coordinate proportionately to the input numeric value  $n$ , serves as the display-output arrangement, and in that the cathode-ray in its movement in the  $x$ -direction delivers an output signal for a distance that is proportional to the deflection in the  $y$ -direction, from which signal a short pulse is extracted.
3. Device according to claim 2, characterized in that a metallic collector electrode (5) is provided in the immediate vicinity of the screen, which electrode delivers a signal upon incidence of the cathode-ray and which is formed in the shape of a triangle bounded by a diagonal of the screen.
4. Device according to claim 2 and 3, characterized in that the diagonal edge of the collector electrode deviates with any nonlinearities of the deflection system in a corrective manner from a straight line.

5. Device according to claim 1 and 2, characterized in that the screen of the cathode ray tube is provided with an opaque triangular mask, and a photocell that is illuminated by the light spot and accordingly delivers an output signal for rounding up is arranged in front of the screen.

6. Device according to claim 1 through 5, characterized in that after input and analog conversion of the entire number, a pulse emitter briefly opens a gate circuit to pick up the voltage of the collector electrode or of the photocell and thus outputs a pulse for storage of an electrode voltage or photocell voltage as a single digit upper (rounded-up) limit in a bit counter or a storage cell of the accounting system to be connected thereto.

7. Device according to claim 1 through 6, characterized in that a second collector electrode or photocell detects the region of the screen not detected according to claim 3 or 5 and outputs, on a second channel, a pulse for storage of the lower limit 0 in a connected counter.

One sheet of drawings follows

Key to Fig. 1a and 1b

Rounding up

Rounding down